CORIOLIS GROUP BOOK

Advanced Graphics Programming Using C/C++

Loren Heiny

John Wiley & Sons, Inc.

New York • Chichester • Brisbane • Toronto • Singapore

Contents

Preface xiii

Who This Book Is For xiii
A Glance Inside xiv
What You'll Need xiv
About the Code xv

Chapter 1 Introduction to Ray Tracing 1

Capturing Images with Ray Tracing 1
Tracing Light Rays 2
Using a Camera Model 2
From Rays to Images 5
Representing a Scene 5
A Simple Ray Tracing Program 5
The Major Data Structures 6
Specifying Colors 6
Specifying Light Sources 6
Specifying Objects 7
Specifying Vectors and Points 8
Describing the World 9
Overview of SIMPLRAY 9
The Main Function 10
Generating Rays 10
Getting Oriented 11
Calculating a Ray 12
Determining What a Ray Hits 16
Working with Planes 16
Representing a Ray 17
Intersecting a Ray and a Plane 18
Representing a Sphere 20
Finding the Closest Object 22
Calculating the Normal 23

Chapter 2 Adding a Lighting Model 25

A Good Lighting Model 25
Ambient Intensity 26
Diffuse Light 26
Specular Light 28

Adding the Light Components 29
Multiple Light Sources 30
Back to Tracing Rays 30
Applying the Lighting Model 32
Calculating the Ambient Color 32
Calculating the Diffuse Color 32
Scaling the Light 34
Adding the Specular Component 34
Calculating the Reflecting Ray 36
Handling Shadows 36
Tracing the Ray 38
Setting the Pixel 40
Compiling SIMPLRAY for DOS 40
Compiling for Windows 41
Choosing a Video Mode 42
Setting the Video Mode 43
DOS Versus Windows Applications 43
Modifying SIMPLRAY 44
Computing Power and Ray Tracing 45

Chapter 3 An Enhanced Ray Tracer 55
Using C++ Effectively 55
Overview of the RAY Program 56
The New Objects 57
Deriving Rectangles 59
Triangle Objects 63
Supporting Spheres 67
Ellipsoids 68
Cylinder Objects 69
Managing Objects 72
An Enhanced Lighting Model 73
New Light Sources 73
Point Light Sources 74
Directed Light Sources 75
Cone Light Sources 76
Scaling Light 77
Adding Fog 78
Managing Light Sources 80
Translucent Objects 80
Antialiasing 81
Bounding Boxes 83

Building a Hierarchy of Objects 85
Supporting Bounding Boxes 86

Chapter 4 Creating a World 133
The Scene Description Language 133
The Parser 136
Reading Tokens 136
Parsing a File 137
Processing Parameters 138
Handling Nested Commands 138
Creating an Object 139
Grouping Objects 139
Handling Parser Errors 140
Using the Scene Description Language 140
Setting the Display Parameters 140
Setting the Viewing Parameters 141
Specifying Lights 142
Specifying Objects 142
Nesting Files 143
Saving an Image 143
Compiling and Using RAY 144
Sample Scenes 145
Things Are Shaping Up 145
Generating Swept Surfaces 146

Chapter 5 Textures and Patterns 173
Rendering a Pattern 173
Setting the Texture 174
Mapping onto Three-Dimensional Objects 175
Rendering a Checker Pattern 176
Mapping the Checker Pattern 177
Rendering Non-Checker Patterns 177
Mapping to Planar Objects 178
Mapping to a Rectangle 178
Mapping to a Sphere and Ellipse 180
Mapping to a Cylinder 181
Defining a Checker Pattern 182
Mapping Images 183
Managing Images 184
From Point to Pixel 185
Defining an Image Map 186

Blended Colors 187
A Textured Scene 189
Constructing the Room 189
Constructing the Cabinets 190
Making the Soup Can 192
Making a Pot 192
Using Bounding Boxes 193
Nothing's Perfect 193

Chapter 6 Adding Animation 199
Animation Overview 199
Supporting Animation 200
The Animating Structure 201
Animating Objects 202
Going the Next Step 204
The Animation Language 204
Specifying the Number of Frames 205
Specifying a Motion Path 205
Moving the Viewer 205
Saving the Image Sequence 206
Playing Back an Image Sequence 207
An Animation Example 207

Chapter 7 Rendering Water and Clouds 215
Designing a Model of Water 215
The Essence of Water 216
Animating Waves 217
Using Normals to Make Waves 218
A Water Object 218
Creating Waves 219
Adding Water to a Scene 221
Sample Water Scene 221
A Watery Glass 222
Extending the Water Model 224
Rendering Clouds 224
A Two-Dimensional Sky 225
Implementing A Sky Plane 226
Calculating the Texture 227
Defining Two-Dimensional Clouds 227
Cloudy Marble 228

Three-Dimensional Clouds 229
Creating Three-Dimensional Clouds 229
The Three-Dimensional Cloud Function 231
Defining Clouds 233
Sample Clouds 233
Tips on Constructing Clouds 236

Chapter 8 Rendering Fractal Mountains 237
Rendering Natural Objects 237
How Fractals Work 238
Using Triangles 238
Generating Mountains 239
Reading the Initial Triangles 240
Setting the Fractal Parameters 241
Subdividing Triangles 242
Writing the Triangles 243
Setting the Color 244
Generating a Random Number 245
Using Bounding Boxes 246
Compiling and Running GENMTN 247
Designing Your Mountains 249
Making More Interesting Images 250

Chapter 9 A PCX Toolkit 271
Overview of PCX Files 271
The PCX File Format 272
The PCX File Header 272
Run-Length Encoding 274
Decoding a PCX File 275
The PCX Toolkit 275
Processing the Header 276
Initializing a Header 277
Writing the Header 278
Writing an Image 278
Processing the Palette 279
Reading a PCX File 279
Reading a Header 280
Reading the Image 280
A Sample Read Function 281
Testing PCXTOOLC 282

Chapter 10 TIFF: A Flexible Image File Format 293
TIFF Overview 293
Working with Classes 294
The Pieces of a TIFF File 294
Working with Tags 296
The Image Format 299
The TIFF.C Toolkit 299
Reading a TIFF File 300
Processing the Tags 302
Determining an Image's Size 303
Reading the Image 303
A High-Level Read Function 304
Writing a TIFF File 305
Writing the Image Data 306
Testing the TIFF Tools 306
Compiling and Running TESTTIFF 308

Chapter 11 Image Processing Essentials 331
Working with Images 331
An Image Processing Toolkit 332
Using Histograms 333
Contrast Enhancement 334
Brightness Adjustment 335
Reducing Noise 336
Sharpening an Image 336
Zooming and Resizing Images 338
Mirroring and Rotating Images 339
Converting a Color Image to Grayscale 340
Colorizing an Image 340
Gamma Correction 341
Testing IMTOOLS.C 342

Chapter 12 Morphing Magic 355
How Morphing Works 355
Warping Images 356
Mapping Images 356
Creating a Simple Morphing Program 357
Controlling the MORPH Program 357
Initializing the Morphing Process 358
Generating Images 359
Moving the Triangle Patches 359

Morphing the Images 360
Determining a Point in a Triangle 361
Generating the Output Color 362
Compiling MORPH 363
Using MORPH 363
Morphing Tips 365

Appendix A Vector Operations 377
Working with Vectors 377
Vector Operations 379

Appendix B A Graphics Toolkit 385
Setting the Mode 385
Setting a Pixel 386
Working with Colors 387
Supporting C and C++ Compilers 388

Appendix C Working with Windows 395
Overview of WINSHELL 395
Using WINSHELL 396
Preparing for Windows 396
Displaying an Image 396
Working with Colors 397
Compiling for Windows 397

Index 401